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Infrared Microspectroscopy of Extremely Deuterium-rich Phases in Interplanetary Dust Particles (IDPs)

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Beamline(s): U10B

Introduction: Hydrogen isotopic anomalies are common and highly variable among cluster IDPs (of probable cometary origin), with values eclipsing those observed in meteorites. The deuterium-rich phases observed in these particles are believed to represent preserved material that formed in the presolar molecular cloud. Previous studies correlating the secondary ion signals of (e.g.) H, C, O with D/H within IDPs suggest that the major D-rich phases are organic. However it is not possible to identify specific chemical compounds using the ion microprobe, and the extremely small sizes of IDPs (~ 1 ng) has precluded the combined molecular and isotopic analyses that have been performed on meteorites.

Methods and Materials: We have obtained complementary transmission electron microscope (TEM), X-ray absorption spectroscopy (XAS, Flynn *et al*. this volume) and Fourier-transform infrared (FTIR) spectroscopy measurements on an IDP with a pronounced D-hotspot where the high D/H ratios are confined to an ~3x3 μm region, as well as an extremely D-poor IDP. The TEM data show that the D-rich hotspot identified with the ion microprobe corresponds to an area of carbon-rich material observed in the microtome thin sections (70 nm thick) of the IDP. We were only able to obtain IR spectra of these particles using the Nicolet Continuum FTIR at Beamline U10B utilizing the high brightness of the synchrotron beam.

Results: FTIR spectra from both the D-rich and D-poor IDPs show features near 3.4 μm that correspond to the CH_2 and CH_3 stretching vibrations in aliphatic hydrocarbons. Normalization of the aliphatic features in the spectra from both IDPs to the Si-O stretch shows that the absorption depth of the aliphatic feature in the D-rich IDP is ~5x that in the D-poor IDP. Aromatic hydrocarbons were below the level of detection in both the D-rich and D-poor IDPs.

Conclusions: Based on FTIR data, there are distinct differences in the organic matter in D-rich IDPs as compared to the organic matter acid-extracted from primitive meteorites (e.g. Murchison CM chondrite). The meteoritic organics have a much higher aromatic:aliphatic hydrocarbon ratio than the D-rich IDPs, and the CH_2/CH_3 band ratio (a measure of aliphatic chain length) is larger in the D-rich IDPs as compared to the meteorite organics.